In the Claims

Applicant has submitted a new complete claim set showing marked up claims with insertions indicated by underlining and deletions indicated by strikeouts and/or double bracketing.

1. (Original) A chemical or biochemical reactor comprising:

a reaction unit including a chamber having a volume of less than 1 ml, an inlet to the chamber connectable to a source of a chemical or biological starting material, and an outlet of the chamber for release of a product of a chemical or biological reaction involving the starting material; and

a collection chamber connectable to the outlet of the reaction chamber, the collection chamber having a volume of greater than 1 liter.

2. (New) A reactor as in claim 1, the reaction chamber having a volume of less than about 100 microliters.

3. (New) A reactor as in claim 1, the reaction chamber having a volume of less than about 10 microliters.

4. (New) A reactor as in claim 1, the reaction chamber having a volume of less than about 5 microliters.

5. (New) A reactor as in claim 1, the reaction chamber having a volume of less than about 1 microliter.

6. (New) A reactor as in claim 1, wherein the reaction unit comprises an etched portion of an article.

7. (New) A reactor as in claim 6, wherein the reaction unit chamber comprises etched silicon.

8. (New) A reactor as in claim 1, wherein the collection chamber comprises etched silicon.

9. (New) A reactor as in claim 1, further comprising a mixing unit fluidly connectable to the inlet of the reaction chamber.

10. (New) A reactor as in claim 9, the mixing unit including an outlet connectable to the inlet of the reaction chamber, a plurality of inlets each in fluid communication with the outlet and a mixing chamber between plurality of inlets and of the outlet.

11. (New) A reactor as in claim 10, wherein the mixing unit chamber is free of active mixing elements.

12. (New) A reactor as in claim 11, wherein the mixing chamber is constructed and arranged to coalesce a plurality of reactant fluids provided through the plurality of inlets and to cause turbulence in the fluids thereby mixing and delivering a mixture of the reactant fluids through the outlet of the mixing chamber.

13. (New) A reactor as in claim 12, wherein the mixing unit includes a fluid flow path between the plurality of inlets and the outlet and a plurality of obstructions in the flow path constructed to cause mixture of fluid flowing through the flow path.

14. (New) A reactor as in claim 9, wherein the mixing unit is attachable to and separable from the reaction unit.

15. (New) A reactor as in claim 9, wherein the mixing chamber includes a volume, between the plurality of inlets and the outlet, of less than 1 liter.

16. (New) A reactor as in claim 9, wherein the mixing chamber includes a volume, between the plurality of inlets and the outlet, of less than 10 microliter.

17. (New) A reactor as in claim 1, further comprising a heating unit having an inlet, and an outlet connectable to the inlet of the reaction chamber, the heating unit separable from and attachable to the reaction chamber.

18. (New) A reactor as in claim 1, further comprising a heating unit having an inlet, and an outlet fluidly connectable to the inlet of the reaction chamber, the heating unit separable from and attachable to the reaction chamber.

19. (New) A reactor as in claim 18, wherein the heating unit includes an inlet, and a plurality of outlets fluidly connected to the inlet.

20. (New) A reactor as in claim 1, further comprising a heating and dispersion unit having an inlet, and an outlet connectable to the inlet of the reaction chamber, the heating and dispersion unit separable from and attachable to the reaction chamber.

21. (New) A reactor as in claim 20, wherein the heating and dispersion unit includes an inlet and a plurality of outlets connected to the inlet.

22. (New) A reactor as in claim 21, further comprising a mixing unit having a plurality of inlets communicating with a mixing chamber, the mixing chamber communicating with an outlet, wherein the outlets of the heating and dispersion units are connectable to the inlet of the reactor, and the inlet of the heating and dispersion unit is connectable to the outlet of the mixing unit.

23. (New) A reactor as in claim 18, wherein the dispersion unit is constructed and arranged to maintain fluid exiting the unit through the plurality of outlets at a temperature of approximately 30°C.

24. (New) A reactor as in claim 1, wherein the reaction chamber is constructed and arranged for cell cultivation.

25. (New) A reactor as in claim 24, wherein the reaction chamber has a surface adapted for immobilization of cells.

26. (New) A reactor as in claim 1, further comprising a separation unit having an inlet and an outlet, the inlet connectable to the outlet of the reaction chamber.

27. (New) A reactor as in claim 26, wherein the separation unit is connectable to and removable from the reaction chamber.

28. (New) A reactor as in claim 26, wherein the separation unit includes an inlet connectable to the outlet of the reaction chamber, a carrier fluid outlet, a fluid pathway connecting the inlet with the carrier fluid outlet, and a size-selective membrane positioned to contact fluid flowing from the inlet to the fluid carrier outlet.

29. (New) A reactor as in claim 28, wherein the membrane has a first side positioned to contact fluid flowing from the inlet to the fluid flow outlet and an opposing second side defining in part a product extraction solvent flow pathway.

30. (New) A reactor as in claim 28, wherein the carrier fluid outlet is connectable to a recovery container for recycling of reaction carrier fluid.

31. (New) A reactor as in claim 1, further comprising at least one sensor of temperature, pH, oxygen concentration, or pressure.

32. (New) A reactor as in claim 31, comprising sensors of each of temperature, pH, and oxygen concentration.

33. (New) A reactor as in claim 1, including a plurality of reaction chambers, attachable to and separable from each other, constructed and arranged to operate in parallel.

34. (New) A reactor as in claim 33, comprising at least 10 reaction chambers constructed to operate in parallel.

35. (New) A reactor as in claim 33, comprising at least 100 reaction chambers constructed to operate in parallel.

36. (New) A reactor as in claim 33, comprising at least 500 reaction chambers constructed to operate in parallel.

37. (New) A reactor as in claim 33, comprising at least 1,000 reaction chambers constructed to operate in parallel.

38. (New) A reactor as in claim 33, comprising at least 10,000 reaction chambers constructed to operate in parallel.

39. (New) A method comprising:

carrying out a chemical or biological reaction in a plurality of reaction chambers operable in parallel, each reaction chamber having a volume of less than 1 ml; and

discharging product of the reaction from the plurality of reaction chambers simultaneously into a collection chamber having a volume of greater than 1 liter.

40. (New) A method as in claim 39, wherein the reaction is one of cell cultivation, catalysis, pharmaceutical production, hazardous chemical production, or chemical remediation of warfare reagents.

41. (New) A method as in claim 40, wherein the reaction involves cell cultivation.

42. (New) A method as in claim 41, involving passing a feedstream across immobilized cells and recovering a protein product in the collection chamber.

43. (New) A method as in claim 39 comprising carrying out the chemical or biological reaction in parallel in at least 10 reaction chambers, and discharging product from each of the reaction chambers into the collection chamber.

44. (New) A method as in claim 39 comprising carrying out the chemical or biological reaction in parallel in at least 100 reaction chambers, and discharging product from each of the reaction chambers into the collection chamber.

45. (New) A method as in claim 39 comprising carrying out the chemical or biological reaction in parallel in at least 500 reaction chambers, and discharging product from each of the reaction chambers into the collection chamber.

46. (New) A method as in claim 39 comprising carrying out the chemical or biological reaction in parallel in at least 1,000 reaction chambers, and discharging product from each of the reaction chambers into the collection chamber.

47. (New) A chemical or biochemical reactor system comprising:

at least ten individuated chemical or biochemical reactors constructed and arranged for operation in parallel, and seperable to a non-parallel operative state and re-attachable to each other for operation in parallel , each including a reaction chamber having a volume of less than 10 ml.

48. (New) A chemical or biochemical reactor system comprising:

a mixing chamber including a plurality of inlets connectable to a plurality of sources of chemical or biochemical reagents and an outlet;

a reaction chamber connectable to and removable from the mixing chamber, the reaction chamber having a volume of less than 1 ml, an inlet to the chamber connectable to and removable from the outlet of the mixing chamber, and an outlet of the chamber for release of a product of a chemical or biological reaction involving the starting material.

49. (New) A reactor as in claim 1, wherein the chemical or biological reaction occurs within at least one cell.

50. (New) A reactor as in claim 1, wherein the chemical or biological reaction comprises producing a protein.

51. (New) A reactor as in claim 1, wherein the chemical or biological reaction includes fermentation.

52. (New) A reactor as in claim 1, further comprising an inlet for adding at least one cell to the chamber.

53. (New) A reactor as in claim 1, further comprising at least one cell.

54. (New) A reactor as in claim 53, wherein the at least one cell is located within the chamber.

55. (New) A reactor as in claim 53, wherein the at least one cell is immobilized.

56. (New) A reactor as in claim 53, wherein the at least one cell is able to grow during the chemical or biological reaction.

57. (New) A reactor as in claim 53, wherein the at least one cell is able to metabolize the starting material.

58. (New) A reactor for carrying out a reaction involving at least one living cell, comprising:

a reaction unit including a chamber having a volume of less than 1 ml, an inlet for adding starting material to the chamber, and an outlet for release of a product of a reaction involving at least one living cell.

59. (New) A reactor as in claim 58, wherein the inlet is connectable to a source of a chemical or biological starting material.

60. (New) A reactor as in claim 58, wherein the reaction comprises a chemical or biological reaction.

61. (New) A reactor as in claim 58, the chamber having a volume of less than about 100 microliters.

62. (New) A reactor as in claim 58, the chamber having a volume of less than about 10 microliters.

63. (New) A reactor as in claim 58, the chamber having a volume of less than about 5 microliters.

64. (New) A reactor as in claim 58, the chamber having a volume of less than about 1 microliter.

65. (New) A reactor as in claim 58, wherein the reaction unit comprises an etched portion of an article.

66. (New) A reactor as in claim 65, wherein the reaction unit chamber comprises etched silicon.

67. (New) A reactor as in claim 58, further comprising a mixing unit fluidly connectable to the inlet of the chamber.

68. (New) A reactor as in claim 67, wherein the mixing chamber includes a volume, between the plurality of inlets and the outlet, of less than 1 liter.

69. (New) A reactor as in claim 67, wherein the mixing chamber includes a volume, between the plurality of inlets and the outlet, of less than 10 microliters.

70. (New) A reactor as in claim 58, further comprising a separation unit having an inlet and an outlet, the inlet connectable to the outlet of the reaction chamber.

71. (New) A reactor as in claim 70, wherein the separation unit is connectable to and removable from the reaction chamber.

72. (New) A reactor as in claim 70, wherein the separation unit includes an inlet connectable to the outlet of the reaction chamber, a carrier fluid outlet, a fluid pathway connecting the inlet with the carrier fluid outlet, and a size-selective membrane positioned to contact fluid flowing from the inlet to the fluid carrier outlet.

73. (New) A reactor as in claim 58, further comprising at least one sensor of temperature, pH, oxygen concentration, or pressure.

74. (New) A reactor as in claim 58, including a plurality of reaction chambers, attachable to and separable from each other, constructed and arranged to operate in parallel.

75. (New) A reactor as in claim 74, comprising at least 10 reaction chambers constructed to operate in parallel.

76. (New) A reactor as in claim 74, comprising at least 100 reaction chambers constructed to operate in parallel.

77. (New) A reactor as in claim 74, comprising at least 500 reaction chambers constructed to operate in parallel.

78. (New) A reactor as in claim 74, comprising at least 1,000 reaction chambers constructed to operate in parallel.

79. (New) A reactor as in claim 74, comprising at least 10,000 reaction chambers constructed to operate in parallel.

80. (New) A reactor as in claim 58, wherein the chemical or biological reaction occurs within at least one cell.

81. (New) A reactor as in claim 58, wherein the chemical or biological reaction comprises producing a protein.

82. (New) A reactor as in claim 58, wherein the chemical or biological reaction includes fermentation.

83. (New) A reactor as in claim 58, further comprising a collection chamber connectable to the outlet of the reaction chamber.

84. (New) A reactor as in claim 83, wherein the collection chamber has a volume of greater than about one liter.

85. (New) A reactor as in claim 58, wherein the starting material comprises cells.

86. (New) A reactor as in claim 85, further comprising at least one sensor of temperature, pH, oxygen concentration, or pressure.

87. (New) A reactor as in claim 85, further comprising temperature control elements constructed and arranged to control temperature at at least one portion of the reactor.

88. (New) A reactor as in claim 58, wherein the starting material comprises a cell nutrient.

89. (New) A reactor as in claim 58, wherein the starting material comprises O_2.

90. (New) A reactor as in claim 58, wherein the starting material comprises CO_2.

91. (New) A reactor as in claim 58, wherein the starting material comprises N_2.

92. (New) A reactor as in claim 58, wherein the starting material is able to alter pH within the chamber.

93. (New) A reactor as in claim 58, further comprising temperature control elements constructed and arranged to control temperature at at least one portion of the reactor.

94. (New) A chemical or biochemical reactor comprising:

a reaction unit including a chamber having a volume of less than 1 ml, an inlet to the chamber connectable to a source of a chemical or biological starting material, and an outlet of the chamber for release of a product of a chemical or biological reaction involving the starting material; and

at least one sensor of temperature, pH, oxygen concentration, or pressure.

95. (New) A reactor as in claim 94, further comprising a collection chamber connectable to the outlet of the reaction chamber, the collection chamber having a volume of greater than 1 liter.

96. (New) A reactor as in claim 94, wherein the reactor comprises sensors each of temperature, pH, oxygen concentration, and pressure.

97. (New) A method, comprising:

providing a reaction unit including a chamber having a volume of less than 1 ml; and

altering the pH of the environment without contacting the chamber with a liquid.

98. (New) A reactor, comprising:

a reaction unit including a chamber having a volume of less than 1 ml; and

a source of gas able to alter the pH of the chamber.

99. (New) A reactor, comprising:

a reaction unit including a chamber having a volume of less than about 1 ml; and

a control system able to control at least one of temperature, pH, nutrient concentration, and oxygen concentration within the chamber.

100. (New) A reactor, comprising:

a reaction unit including a chamber having a volume of less than about 1 ml;

a detector able to detect at least one of temperature, pH, nutrient concentration, and oxygen concentration within the chamber; and

at least one of a heat exchanger, an oxygen input, a carbon dioxide input, a nitrogen input, and a nutrient input, that each is responsive to the detector.

101. (New) A reactor, comprising:

a reaction unit including a chamber having a volume of less than about 1 ml; and

a separation membrane in fluid communication with the chamber.

102. (New) A reactor as in claim 101, wherein the membrane is a size-selective membrane.

103. (New) A reactor as in claim 101, wherein the membrane is an ionic membrane.